Problem 24

a) True. Suppose the sender has a window size of 3 and sends packets 1, 2, 3 at $t0$. At $t1$ $(t1 > t0)$ the receiver ACKS 1, 2, 3. At $t2$ $(t2 > t1)$ the sender times out and resends 1, 2, 3. At $t3$ the receiver receives the duplicates and re-acknowledges 1, 2, 3. At $t4$ the sender receives the ACKs that the receiver sent at $t1$ and advances its window to 4, 5, 6. At $t5$ the sender receives the ACKs 1, 2, 3 the receiver sent at $t2$. These ACKs are outside its window.

b) True. By essentially the same scenario as in (a).

c) True.

a) True. Note that with a window size of 1, SR, GBN, and the alternating bit protocol are functionally equivalent. The window size of 1 precludes the possibility of out-of-order packets (within the window). A cumulative ACK is just an ordinary ACK in this situation, since it can only refer to the single packet within the window.

Problem 31

$$EstimatedRTT = xSampleRTT + (1-x)EstimatedRTT$$

$$DevRTT = y\left|SampleRTT - EstimatedRTT\right| + (1-y)DevRTT$$

$$TimeoutInterval = EstimatedRTT + 4 * DevRTT$$

After obtaining first sampleRTT is

$$EstimatedRTT = 0.125*106 + 0.875*100$$
$$= 100.75ms.$$

$$DevRTT = 0.25*\left|106 - 100.75\right| + 0.75*5$$
$$= 5.06ms.$$

$$TimeoutInterval = 100.75 + 4*5.06$$
$$= 120.99ms.$$

After obtaining second sampleRTT = 120ms:

$$EstimatedRTT = 0.125*120 + 0.875*100.75$$
$$= 103.15ms.$$

$$DevRTT = 0.25*\left|120 - 103.15\right| + 0.75*5.06$$
$$= 8ms.$$

$$TimeoutInterval = 103.15 + 4*8$$
$$= 135.15ms.$$

After obtaining Third sampleRTT = 140ms:

$$EstimatedRTT = 0.125*140 + 0.875*103.15$$
$$= 107.76ms.$$

$$DevRTT = 0.25*\left|140 - 107.76\right| + 0.75*8$$

$$= 14.06ms$$

$$TimeoutInterval = 107.76 + 4*14.06$$
$$= 164ms$$

After obtaining fourth sampleRTT = 90ms:

$$EstimatedRTT = 0.125*90 + 0.875*107.76$$
$$= 105.54ms$$

$$DevRTT = 0.25*|90 - 105.54| + 0.75*14.06$$
$$= 14.42ms$$

$$TimeoutInterval = 105.54 + 4*14.42$$
$$= 163.22ms$$

After obtaining fifth sampleRTT = 115ms:

$$EstimatedRTT = 0.125*115 + 0.875*105.54$$
$$= 106.71ms$$

$$DevRTT = 0.25*|115 - 106.71| + 0.75*14.42$$
$$= 12.88ms$$

$$TimeoutInterval = 106.71 + 4*12.88$$
$$= 158.23ms$$

Problem 36

Suppose packets n, n+1, and n+2 are sent, and that packet n is received and ACKed. If packets n+1 and n+2 are reordered along the end-to-end-path (i.e., are received in the order n+2, n+1) then the receipt of packet n+2 will generate a duplicate ack for n and would trigger a retransmission under a policy of waiting only for second duplicate ACK for retransmission. By waiting for a triple duplicate ACK, it must be the case that *two* packets after packet n are correctly received, while n+1 was not received. The designers of the triple duplicate ACK scheme probably felt that waiting for two packets (rather than 1) was the right tradeoff between triggering a quick retransmission when needed, but not retransmitting prematurely in the face of packet reordering.

Problem 40

a) TCP slowstart is operating in the intervals [1,6] and [23,26]
b) TCP congestion avoidance is operating in the intervals [6,16] and [17,22]
c) After the 16^{th} transmission round, packet loss is recognized by a triple duplicate ACK. If there was a timeout, the congestion window size would have dropped to 1.
d) After the 22^{nd} transmission round, segment loss is detected due to timeout, and hence the congestion window size is set to 1.
e) The threshold is initially 32, since it is at this window size that slow start stops and congestion avoidance begins.
f) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 16, the congestion windows size is 42. Hence the threshold is 21 during the 18^{th} transmission round.

g) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 22, the congestion windows size is 29. Hence the threshold is 14 (taking lower floor of 14.5) during the 24^{th} transmission round.

h) During the 1^{st} transmission round, packet 1 is sent; packet 2-3 are sent in the 2^{nd} transmission round; packets 4-7 are sent in the 3^{rd} transmission round; packets 8-15 are sent in the 4^{th} transmission round; packets 16-31 are sent in the 5^{th} transmission round; packets 32-63 are sent in the 6^{th} transmission round; packets 64 – 96 are sent in the 7^{th} transmission round. Thus packet 70 is sent in the 7^{th} transmission round.

i) The threshold will be set to half the current value of the congestion window (8) when the loss occurred and congestion window will be set to the new threshold value + 3 MSS . Thus the new values of the threshold and window will be 4 and 7 respectively.

j) threshold is 21, and congestion window size is 1.

round 17, 1 packet; round 18, 2 packets; round 19, 4 packets; round 20, 8 packets; round 21, 16 packets; round 22, 21 packets. So, the total number is 52.

Problem 5

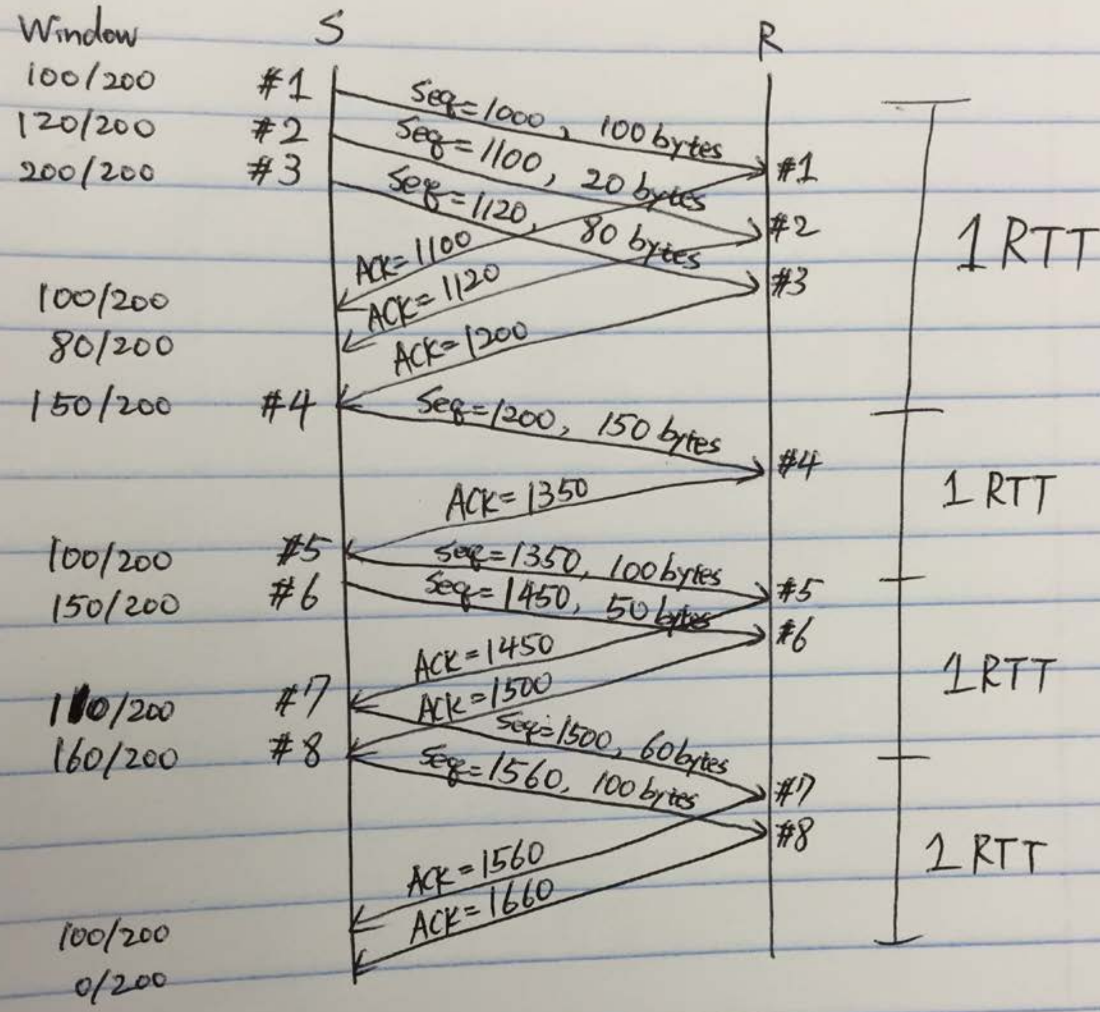
Note that in TCP, both sequence numbers and ACK numbers are counted in bytes. Assume that the current TCP connection is using selective repeat with fixed window size (i.e., N=200 bytes) at steady state say t=100s. Starting from t=100s, at the TCP sender, the series of segments labeled with #1, #2, #3, #4, #5, #6, #7, #8, ... are waiting for transmission, and the corresponding segment size (counted in bytes) is 100B, 20B, 80B, 150B, 100B, 50B, 60B, 100B, ..., respectively. Assume that at t=100s, the TCP sender sequence number starts from 1000 (in byte), and the receiver sequence number starts from 2000 (in byte). The receiver does not have data (except the ACK packets) to send back to the sender. Assume that the round trip time (RTT) is fixed and an ACK is sent when the receiver receives each TCP segment (i.e.., no delayed ACK is used here). You are asked to draw the packet transmission flow chart to answer the following questions:

1. What is the sequence number and ACK number used when transmitting segment #8 (with packet size 100B)?

2. Counted from t=100s (when starting to transmit segment #1), how many RTTs are needed when the ACK for TCP segment #6 (50B) arrives at the sender?

HW#4. Pr5.

Window size = 200 bytes



1. Seq# = 1560

   ACK# = 1660

2. 3 RTT